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METHODS OF STUDYING THE BASICS OF CHEMICAL PRODUCTION IN INSTITUTIONS OF GENERAL SECONDARY EDUCATION

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INTRODUCTION

Modern progress in the development of equipment and technologies is reaching large scales. That is why, in our time, not just high-level specialists are becoming the most sought-after and valuable, but specialists who can orient themselves in the flow of constantly changing information, master new technologies, mechanisms of operation of modern devices, devices and, in general, production processes, conduct research in specific fields of knowledge. Chemical industries are trying to reach a new level to automate the production process, to minimize additional costs, that is, to direct their development in the direction of the introduction of innovations and the use of modern devices and equipment in the production process. But unfortunately, in Ukraine, this development is somewhat slowed down. This, on the one hand, is connected with the lack of funding aimed at the development of the chemical industry and, on the other hand, the lack of trained, highly qualified specialists to work in chemical industries. This is also evidenced by the number of vacancies (especially in the Sumy region) that are open for employment in chemical production. But taking into account the requirements for a modern specialist, it is pretty challenging to find a highly qualified specialist. In our opinion, such specialists should be trained in the process of training in general secondary education institutions. This determines the need to strengthen the emphasis of students' training in chemistry lessons in general secondary education institutions on the formation of their knowledge about the basics of chemical production, modern technologies, devices, the chemical-technological process, etc. This conclusion was based on the results of the students' questionnaire, which showed the insufficiency of the formed knowledge about the basics of chemical production – 74 % of 52 respondents feel the need to pay more attention to the study of the basics of chemical production in chemistry classes.

The listed shortcomings result from the low level of student's knowledge of the basics of chemical production and, accordingly, the low formation of subject competence in chemistry and the inability to operate with the acquired knowledge and skills.

At the same time, the analysis of the current state of pedagogical science confirmed the lack of a methodical system for studying the basics of chemical production in the chemistry course of secondary education institutions. At the same time, we state the presence of various methods, technologies, and forms that are presented by scientists for use in the professional activities of teachers.

Thus, the issue of forming knowledge of the basics of chemical production and the ability to evaluate their activities in students of secondary schools while contributing to the formation of the subject competence of students in chemistry is quite relevant and unexplored in the modern educational space. And the development of a methodical experimental system for studying the basics of chemical production in the course of chemistry Institution of General Secondary Education requires substantiation and research.

1. Formation of knowledge about the basics of chemical production as components of subject competence of students in chemistry

Modern youth must be ready to use the current technical assets of civilization, be able to use them safely, be environmentally conscious, and quickly adapt to the changing world of technology. Education should provide training of highly qualified specialists with formed knowledge of modern equipment, technologies, and methods of production management, which are rapidly updated today. As the results of labor market monitoring show, the educational and qualification potential of society in the polytechnic direction does not meet its demands. This has a negative impact on the quality of labor resources and leads to the fact that some specialists need further training and are not competitive in the modern labor market, as they are unable to independently learn how to use modern equipment in production. This is evidenced by the number of vacancies (mainly in the Sumy region) that are open for employment in chemical production. But considering the requirements for a modern specialist, finding a highly qualified specialist is quite challenging. That is why, in our opinion, the training of such highly skilled specialists should begin with institutions of general secondary education.

One of the reasons for this problem is the insufficient level of formed knowledge about the basics of chemical production among students of Institution of General Secondary Education, the ability to give a comprehensive assessment of their activities.

The study of issues related to solving the process of forming subject competence in chemistry is one of the priority areas of modern pedagogical science.

The general provisions of introducing the principles of competence education into the educational process are substantiated in the works of I. Bekha, S. Honcharenko, V. Sergiyenko, V. Syrotyuka and others; at the level of formation and development of key competencies – in the works of

M. Burdy, N. Bibyk, L. Vashchenko, O. Lokshina and others; the formation of subject competencies in chemistry is highlighted in the works of O. Babenko, A. Hrabovoy, O. Pometun, M. Savchyn et al. The problems of polytechnic education are described in the works of O. Bugayova, S. Velichko, S. Honcharenko, V. Vovkotruba, G. Imasheva, V. Ilchenko, M. Sadovoy, E. Korshaka, M. Martyniuk, M. Shuta, etc.; the competence approach is reflected in the works of O. Lyashenko, M. Golovka, T. Zasekinoi and others; polytechnic competence – in the works of L. Borisova, V. Bryukhovetskyi, A. Drobina, O. Mikhnina and others.

Taking into account the contribution of scientists to the study of the problem of the development of competence education in Ukraine, it should be noted that insufficient attention is paid to the formation of knowledge about the basics of chemical production as a constituent element of the subject competence in the chemistry of students of secondary schools, as evidenced by the analysis of scientific and methodological literature. However, this problem, given the task of reforming public secondary and professional education institutions, must find a new scientific justification and practical solution.

Analyzing the scientific and pedagogical literature and regulatory documents, we compared the education system of the past years (1950–2022). We concluded that previously great attention in the content of education was paid to the applied nature of teaching chemistry. That is why we warn against the flourishing of chemical production until the 2000s. Previously, in the context of education, much attention was paid to implementing the polytechnic principle in the chemistry teaching, which is not even mentioned now.

Chemistry, as an educational subject, is designed to form in students an idea of scientifically based rules and norms for the use of substances and materials, and together with other natural sciences, to form the foundations of a healthy lifestyle and competent behavior of students in everyday life, in nature, contributing to the formation of subject competence in chemistry. Studying chemistry should not only provide knowledge of the surrounding reality but also equip students with the knowledge necessary for practical activities[1, 2, 3].

[1] Tarasenko G., Mudrak O., Mudrak G., Nesterovych B. Environmentalism of the educational process as a key to successful worldview education of young generations. Paradygmatyczne aspekty i dylematy rozwoju nauk i edukacji : monografia / ed.: J. Grzesiak, I. Zymomrya, W. Ilnytskyj. Konin – Użhorod – Melitopol – Chersoń Krzywy Róg, 2019. P. 163–174. URL: https://u.to/MU2MHA.

[2] Voronenko T. Project activities of students in learning natural sciences. *Biology and chemistry in native school*. 2015. № 4. S. 20–24.

[3] Curriculum for institutions of general secondary education. Chemistry 7–9 grades. URL: http://surl.li/euwf.

It should be noted that in current conditions, one of the essential principles of updating the content of chemical education in Institution of General Secondary Education is the strengthening of its applied orientation, which means the orientation of the content and methods of teaching chemistry at school to the development of student's abilities to independently acquire and apply chemical knowledge necessary for solving practical problems tasks[4, 5].

The insufficient number of hours allocated to the study of the subject significantly limits the possibilities of implementing the applied chemistry orientation in the lessons. For this reason, teachers are forced to devote themselves to studying the basics of science itself.

From work experience, we state that the use of extracurricular activities that contribute to the expansion of students' knowledge and outlook, strengthen interdisciplinary connections, form practical abilities and skills, etc., is relevant to learning the basics of chemical production in the chemistry course. In the framework of extracurricular activities, the organization of student research is effective and is quite actively used in other countries. For example, among the various areas of extracurricular work in the Republic of Sakha (Yakutia) in recent years, educational expeditions have been widely developed.

Analyzing the content of Ukrainian education in the past years (50-the 80s), when the chemical branch of industry flourished, it was established that the content of chemical education was completely different. During the study of chemistry to improve the training of students in the basics of chemical production, great attention was paid to solving problems with production content, conducting practical work and production excursions to local enterprises. In the late 1950s, mandatory production practices in workshops became widespread and chemical laboratories of enterprises operating electives, etc.[6].

One of the essential principles in teaching chemistry is the didactic principle – the connection between learning and life[7]. The importance of implementing this principle in practice is due to the detachment of chemistry

[4] Extracurricular work in chemistry: method. manual for students of the Faculty of Chemistry and Pharmacy majoring in "Secondary Education (Chemistry)" Ed. OHM. Chebotaryov, O. M. Rakhlytska, O. M. Guzenko, T. M. Shcherbakov. Odesa : Odessa. national University named after I. I. Mechnikova, 2020. 98 p.

[5] Latest news about Education and Training in the European Union. Education and Training. URL: https://ec.europa.eu/education.

[6] Trends and problems of the development of modern chemical education. Collection of scientific works of the 1st All-Ukrainian scientific and practical conference. Ivano-Frankivsk, May 23–24, 2019. URL: https://chemeducation.pnu.edu.ua/wp-content/uploads/sites/14/2019/06/Konf.pdf.

[7] Zablotska O. Impact on the environment as a link in the chain of characteristics of substances. *Biology and chemistry in a modern school*. 2013. № 6. P. 7–13.

from the student's life experience and the great abstractness of its fundamental concepts.

Today, the chemical industry is one of the most important industries in the world economy. Nowadays, Ukraine is one of the leading suppliers of agricultural products (grains, legumes, etc.). The use of mineral fertilizers in order to obtain good harvests, intensification of production processes, etc., is increasingly widespread in agriculture. On the one hand, the chemical industry contributes to the strengthening of scientific and technical progress. On the other hand, it is one of the most powerful polluters of the environment.

We consider the chemical industry as a complex industry that provides all branches of the economy (chemical, technological, material), provides humanity with goods for mass consumption.

The modern development of the chemical industry is extremely high, allows the creation of new materials with predetermined properties, promotes the complete processing of waste from other branches of the economy, and even the use of secondary raw materials for the manufacture of products for repeated consumption and ensures the manufacture of goods for mass consumption.

Studying the basics of chemical and technological processes in Institution of General Secondary Education is an important means of forming students' individually necessary life competencies and, in general, subject competence in chemistry[8]. Studying the basics of chemical production ensures the implementation of one of the main principles – the connection of learning with life, scientific knowledge, professional orientation, etc.

If previously, the chemistry program[9] provided for the study of individual chemical and technological processes, in particular, the production of acids, the production of mineral fertilizers and plant protection products, the production of metals (cast iron, steel, aluminum, and others), oil processing, coal coking, then in modern programs[10] the number of represented chemical industries was reduced by more than half. Although consideration of the general foundations of the modern chemical industry is carried out precisely during the study of the above industries, the main attention should be paid not so much to technologies and processes but to the chemistry of production processes.

[8] Teaching chemistry to primary school students: methodical guide. Velichko L. P., Voronenko T. I., Netrybiychuk O. S. Kyiv, 2019 192 p.

[9] Chemistry 10–12 grades: Programs for specialized training of students of general educational institutions: standard level, academic level, specialized level and in-depth study. Compilers S. S. Fitsailo, O. A. Dubovyk Ternopil, 2010. 248 p. *School of Chemistry*. URL: https://u.to/xU2MHA.

[10] Meteiko A. V. Formation of chemical competence in students of general secondary education institutions. URL: https://u.to/X9xxHA.

Let's consider the issue of the formation of students' competencies in the process of learning in the Institution of General Secondary Education. In particular, let's focus on the subject of competence in chemistry.

In the Law of Ukraine "On Education," competence is interpreted as "a dynamic combination of knowledge, abilities, skills, ways of thinking, views, values, and other personal qualities, which determines a person's ability to successfully socialize, conduct professional and/or further educational activities"[11].

The Law "On Education" defines and presents ten groups of competencies:

Communication in the state language	Communication in foreign languages	Mathematical literacy	Competencies in natural sciences and technologies	Informational - digital competence
The ability to learn throughout life	Environmental literacy and healthy life	Social and civic competences	Entrepreneur-ship	General cultural literacy

In the project "New Ukrainian school: the basics of the standard of education," the learning process is inseparably combined with the real world and the needs that life poses to a person[12].

In a modern school, a competent student is considered a person with a formed culture of thinking, capable of self-development, independent decision-making, etc. A competent student should embody the following qualities:

- self-confidence, constant expansion of one's capabilities, realization of intended goals;
- the ability to act adequately in a dynamic world, unforeseen situations, professional mobility;
- lifelong learning ability;
- adequacy of assessment of one's own strengths, ability to find opportunities for their implementation;
- the ability to make decisions and achieve results in accordance with the set goal;
- the ability to take responsibility for one's actions, to be tolerant of other people.

[11] Formation of key competences of students in chemistry lessons through the use of innovative technologies. URL: https://u.to/BOJxHA.

[12] "New Ukrainian school". URL: https://mon.gov.ua/ua/tag/nova-ukrainska-shkola.

Knowledge is an important competence element and should be thorough, scientific, systematic, and comprehensive.

When studying the Institution of General Secondary Education program in chemistry for grades 7–9, we highlight key competencies and educational resources for forming knowledge about the basics of chemical production.

Subject chemical competence of students is a component of the key competencies "Competence in the field of natural sciences" and "Environmental competence," which involves: awareness of cause-and-effect relationships in nature and its integrity; the use of chemical knowledge to explain the benefits and harms of achievements of chemistry and chemical technology for humans and the environment; arranging one's living environment without harming oneself, other people and the environment; maintaining a healthy lifestyle; safe handling of chemical compounds and materials in everyday life; participation in the implementation of projects aimed at improving the state of the environment thanks to the achievements of chemical science; compliance with the rules of ecologically balanced behavior in the environment[13].

Subject competence in chemistry is considered as a student's ability to navigate life situations, make evaluative conclusions, and effectively solve current problems that involve working with such concepts as chemical elements, substances, chemical phenomena, and chemical production[14]. That is, studying the basics of chemical production is one of the conditions for the formation of subject competence in chemistry.

Subject competence in chemistry is formed as a result of cognitive activity regarding objects of real reality, which are studied by the chemical industry: these are chemical phenomena, substances, materials, as well as fundamental problems that humanity solves using chemical science.

In the process of a detailed study of modern chemistry curricula[15], we noticed that the study of issues related to the basics of chemical production is followed in the implementation of all four content lines, namely: "Environmental safety and sustainable development," "Civil responsibility," "Health and Safety," "Entrepreneurship and Financial Literacy."

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[13] Kuzmenko M. V., Vakal Yu.S. The use of modern IT technologies in the study of chemical production in the course of chemistry Institution of General Secondary Education. "Educational and scientific dimensions of natural sciences": a collection of materials of the 3rd All-Ukrainian Correspondence Scientific Conference. Sumy, 2022. P. 98–100.

[14] Chemistry 10–12 grades: Programs for specialized training of students of general educational institutions: standard level, academic level, specialized level and in-depth study. Compilers S. S. Fitsailo, O. A. Dubovyk Ternopil, 2010. 248 p. *School of Chemistry*. URL: https://u.to/xU2MHA.

[15] Curriculum for institutions of general secondary education. Chemistry 10–11 grades. URL: http://surl.li/euwg.

The structure of subject competence in chemistry includes the following components: knowledge (cognitive), activity (behavioral) and value (motivational)[16].

The knowledge component of the subject competence in chemistry highlights the assimilation of leading scientific ideas and concepts, on which the chemical picture of the world is built… and also covers information about the global problems of humanity: energy, environment, food, raw materials – and, in general, the problems of sustainable development of society.

Active component – its foundation is a knowledge component on the basis of which specific theoretical and practical actions are performed. This is primarily the mastery of the chemical language, which is used to describe observations, analyze facts, characterize substances and phenomena, formulate conclusions, explain natural phenomena from the point of view of chemistry, analysis of chemical information, etc. The practical part of the program is represented by such laboratory works as the study of physical and chemical phenomena, the study of physical and chemical properties of substances, the extraction of substances, the identification of substances by certain characteristics, the production of solutions, the solving of calculation and experimental problems, the assembly of devices for the extraction of substances, the assembly of models molecules If we consider the activity component from the point of view of the content line "Methods of scientific knowledge in chemistry" of the State Standard of Education, then it is necessary to provide not only familiarization with the methods of recording scientific observations and their reproduction at the elementary level but also with theoretical ideas about the forms of scientific knowledge, about activities aimed at for generalization, explanation, forecasting, modeling of chemical phenomena.

The valuable component is based on the student's awareness of the role of chemistry in the knowledge of the surrounding world and everyday life (careful attitude to nature and health) in solving global problems of humanity, its sustainable development and the personal needs of every person's life support, as well as … critical attitude to information of a chemical nature, a reflection of one's own activity[17].

It is obvious that solving calculation problems in chemistry contributes to the development of mathematical competence. Looking at the content of all

[16] Meteiko A. V. Formation of chemical competence in students of general secondary education institutions. URL: https://u.to/X9xxHA.

[17] Curriculum for institutions of general secondary education. Chemistry 7–9 grades. URL: http://surl.li/euwf

sections, you can see that each topic contributes to the formation of environmental literacy and a healthy lifestyle[18].

Modern chemistry curricula have separate topics ("Chemistry and human progress") that contribute to a careful consideration of the basics of chemical production, consideration of new substances and materials, the development of the latest production technologies, and the study of environmental safety.

An interesting part of the program is the study of issues of modern chemistry, namely an introduction to green chemistry "as a new trend in the development of the modern chemical industry, scientific research and the outlook of the young generation of chemists. Its task is to help humanity in the selection of such raw materials and schemes of technological processes that generally exclude the use of any harmful starting substances or their formation in the process of production/use of chemical products"[19].

But, in our opinion, important topics such as electrolysis – the main way of extracting alkali metals, etc. are excluded from the educational programs.

Revealing the manifestation of the laws of chemistry in practice, firstly, it is necessary to show how chemical knowledge is applied by society. And this knowledge is used to obtain new substances or types of energy.

Therefore, the formation of knowledge about the basics of chemical production is an important component of subject competence in chemistry. An analysis of chemistry curricula revealed that insufficient hours are devoted to the study of the basics of chemical production. In our opinion, it is necessary to strengthen the applied nature of the content of chemistry education programs, to restore the study of important topics that are currently left for independent study.

2. Comprehensive approach to the system of knowledge about chemical production

Nowadays, there is a contradiction between the volume of programmed material and the number of hours devoted to its study, especially to practicing problem-solving and task-performance skills; contradictions between the level of knowledge acquired by the student following the general education program and the requirements for admission to higher education institutions; there are problems of choosing the level of complexity of the studied material; application of theoretical knowledge acquired by students in lessons in their practical activities.

[18] Voronenko T. I. Elective course in environmental chemistry as a component of students' pre-professional training. *Biology and chemistry today school*. 2012. № 2. P. 34–37.

[19] Voronenko T. Implementation of the ecological component of the course. 2013. URL: https://u.to/dU2MHA.

In general, the main task of the teacher is to help the student to develop as an individual who will be able to adapt to current conditions, to be able to independently find and solve problems, and apply his knowledge and skills in practical activities.

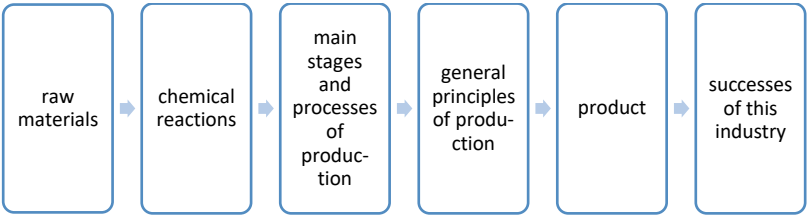
Most teachers in their lessons pay attention to the application of chemistry in human life and introduce them to the most important chemical productions. Still, nowadays, the number of hours for their study is constantly decreasing. A significant number of teachers pay insufficient attention to familiarizing students with the general scientific foundations of modern chemical production, using only textbook material and not revealing the essence of chemical production enough because they are not sufficiently familiar with it. At the same time, there is too little literature that would help the teacher understand the fundamentals of modern chemical production. Although studying the basics of modern chemical production is one of the tasks of forming subject competence in chemistry. Therefore, highlighting in chemistry lessons modern methods of chemical production, which are easily assimilated by students, studying the simplest schemes of technological processes of individual industries, revealing the meaning of the manufactured product both in individual industries and in agriculture – all this will greatly help the teacher to expand students' knowledge of the basics of chemistry industries and will contribute to the overall formation of subject competence in chemistry.

Nowadays, a contradiction has arisen between the need to strengthen the applied orientation of chemistry education in Institution of General Secondary Education and the limited time allocated to the study of chemistry by current educational programs. In addition, in the methodology of classroom and extracurricular work, the issues of implementing the applied orientation of chemistry education are not sufficiently developed.

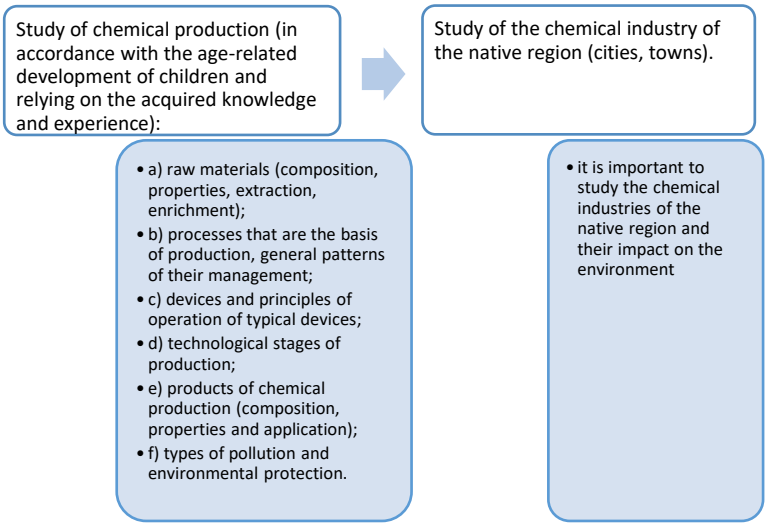
The sequence of study of chemical products, in general, may be different depending on the nature of the specific production, preliminary training of students and other circumstances. However, the developments of well-known methodologists and the experience of advanced teachers[20, 21] testify that it is better to work according to the following scheme:

[20] Voronenko T. I. Elective course in environmental chemistry as a component of students' pre-professional training. *Biology and chemistry today school. 2012*. № 2. P. 34–37.

[21] Meteiko A. V. Formation of chemical competence in students of general secondary education institutions. URL: https://u.to/X9xxHA



We suggest that the study of the basics of chemical production be organized as follows:



In the course of chemistry, during the presentation of material on chemical production, it is quite important to bring to the minds of students the connection between science and production and to show that chemical science, which at one time arose based on production, serves the needs of people and is of great importance for the development of society, although and causes considerable pollution to the environment.

The main principles when studying the basics of chemical production are scientificity, clarity, connection with life, and the active activity of students. When planning classes within the framework of studying the basics of chemical production, great attention should be paid to interactive forms of learning, the independent activity of students, formation and development of

the ability to navigate in the modern information space. The main methods and forms of education that we would recommend in the process of studying the basics of chemical production are frontal heuristic conversation, problem-based learning, independent research activities of students, the research study of phenomena, the use of chemical and imaginary experiments, visual aids, technical teaching aids, drawing up and solving calculation and quality tasks with production, environmental and economic content, modeling and design, creating a project, conducting business and interactive games, virtual tours and 3D tours of production. In our opinion, the extensive use of modern IT technologies is also an integral part of the classes, both for the teacher's explanation and for the student's individual work.

Thus, using these teaching methods makes it possible to achieve an active mental activity in students in class. It is effective to create a problem situation that puts the student in front of the need to think, reason, look for connections between an unfamiliar phenomenon and an already known one, compare different facts and find similarities or differences between them to accept or reject the proposed hypothesis.

The acquisition of solid knowledge is also facilitated by practical and laboratory work carried out in chemistry classrooms and laboratories, excursions and 3D production tours, work of students in subject groups, etc.

A chemical experiment helps students learn the theoretical material necessary to understand chemical production. Through practical and laboratory work under the teacher's guidance, students acquire certain skills and abilities, which also contribute to a better understanding of chemical production. Practical classes are essentially one of the most effective methods of familiarizing students with the scientific foundations of chemical production. After all, it is known that those chemical reactions carried out by students in glassware in small quantities in the chemistry laboratory are carried out at chemical plants on a large scale and in special equipment. We are convinced that there has always been and still is a close connection between the chemical laboratory and large-scale production.

In the methodological literature, there are examples of demonstrations of some devices in which processes similar to chemical plants take place. Using them will also help students better learn and understand the essence of chemical production. Experimental extraction of substances in the laboratory will reveal to students the chemical basis of the production of these substances at plants, and familiarization with the chemical production of various substances and their use will form in students an idea of the chemical economy of our country.

During the study of chemical production, it is necessary to gradually familiarize students with such principles as the use of catalysts, optimal

temperatures and pressures, counterflow, circulation of reactants, and enrichment of raw materials; to acquaint them with the scientific principles of accelerating chemical reactions, which help to rationally use reactive substances, as well as obtained new products. It is necessary to show how the chemical industry uses continuous flow, electrification, mechanization, and automation, as well as the connection of the chemical industry with other branches of the national economy.

We believe that the study of the basics of chemical products should not be started until students are familiar with the theoretical basis of this production. It is necessary for students to master the physical and chemical properties of this substance, to know the use of this substance in industry, and only then to start studying chemical production. We believe that the study of chemical production must necessarily be combined with the demonstration of attempts, diagrams of production processes, models of individual units, operating models that reflect the essence of the work of this production, with the demonstration of video films, with the solution of problems, especially on production topics and conducting excursions.

In the process of researching the problem of learning the basics of chemical production, we considered several approaches used by famous teachers and methodologists in the process of teaching this aspect.

Thus, some scientists T. Voronenko, N. Kucherenko and others[22] in the process of studying chemical industries, prefer a problem-based approach. Using various problem situations has the most effective developmental impact on students. You can offer students the following problematic situations: “By which reactions can a product be obtained from this raw material? Or, propose to develop approximate safety rules for workers of the chemical industry under study." The assimilation of the material for chemical production is facilitated by solving the problems of the production content.

From the work experience of N. Burynska[23], during the study of chemical production, the teacher should use the techniques of comparison, analysis, synthesis, abstraction, generalization, the ability to distinguish the main features of objects and phenomena to choose the most significant of them, etc. In the process of studying chemical productions, visual aids, elements of design and construction of productions, practical and laboratory work, independent work of students with a textbook, tables, and didactic material must be used, and interdisciplinary connections must also be established.

[22] Voronenko T. Implementation of the ecological component of the course. 2013. URL: https://u.to/dU2MHA

[23] Naumenko O. M. Methodology for preparing classes on the study of chemical technological processes using Internet resources. *Information technologies and teaching aids*. 2014. Vol. 41, № 3. P.178–186.

According to Nina Mykolaivna, it is quite effective to conduct production tours and organize practical classes and observations of students in chemical shops and

By the way, in the leading universities of European countries, there are separate chemical specialties with chemical engineering. Having read the curriculum[24], it is interesting that much attention is paid to the study of industrial chemical processes for the production of various materials. Therefore, to enter such specialties, students must have, following the requirements, a high level of knowledge of the basics of chemical production, which they receive in the course of their studies.

After studying the recommendations of the above-mentioned methodologists, we concluded that, indeed in the process of studying one or another chemical production, it is necessary to apply a large number of methods and techniques to achieve a good mastery of the material.

In the course of the research, it was found that business and interactive games are more effective in grades 8–9 and project technologies in grades 10–11.

When considering the features of chemical production, it is necessary to mention the following general principles and methods of production with examples:

1. Continuous process – a chemical-technological process in which raw materials are continuously fed into reaction apparatuses, chemical components continuously react under constant conditions, and the reaction product is continuously removed. (Iron production, lime burning, contact method of sulfuric acid production, ammonia synthesis, water gas production).

2. A periodic (intermittent) process is a type of chemical-technological process in which the mixing of reactants, the reaction, and the release of reaction products follow one another and are repeated periodically after certain intervals of time.

3. The principle of countercurrent is the principle of a chemical-technological process in which different substances move toward each other. Anti-flow is used to create optimal conditions for metabolism or energy. (Contact method of sulfuric acid production, ammonia synthesis).

4. The principle of cyclicity is a chemical-technological process, according to which unreacted and returned from the process starting or auxiliary substances are sent back to the apparatus. The use of this principle

[24] Extracurricular work in chemistry: method. manual for students of the Faculty of Chemistry and Pharmacy majoring in "Secondary Education (Chemistry)" Ed. OHM. Chebotaryov, O. M. Rakhlytska, O. M. Guzenko, T. M. Shcherbakov. Odesa : Odessa. national University named after I. I. Mechnikova, 2020. 98 p.

contributes to a more complete and rational use of substances. Most often, the principle is used in continuous processes. (Synthesis of ammonia).

5. The principle of the fluidized bed is the principle of the chemical-technological process, in which the gaseous starting substances are blown through the holes at the bottom of the apparatus, and the solid starting substances that are in it “boil," being in a dynamic state all the time. At the same time, the reactions take place in the fluidized bed itself. (Production of sulfur (IV) oxide, production of water gas).

The teacher should also draw students’ attention to the fact that the reduce economic losses in the production process to protect the environment from pollution, it is quite important to solve the problem of integrated use of chemical raw materials to create closed waste-free production cycles at enterprises and to improve existing ones.

The current chemical industry is a highly developed and complex industry. It produces thousands of products, the scale of production depending on their importance for the national economy and application areas.

In the process of studying chemical production, as mentioned above, different methods can be used, but a combination of several different methods and techniques is effective.

Events such as scientific conferences, research works, discussions, etc., will allow chemistry teachers in a certain system to form students’ knowledge about chemical products and to educate ecological culture.

Let’s dwell on the role of business games in the process of studying chemical industries.

A business game is a model of the decision-making process in a real situation with a clearly defined structure. The business game allows you to create production situations, during which students need to find the correct line of behavior, and the optimal solution to the problem, in accordance with the real circumstances of production simulated in the game. During the game, students need to mobilize all their knowledge, experience and imagination as much as possible. It is especially valuable that in the process of playing, the ability to think systematically and productively is created, and the desire to find new ideas is revealed, and this is already a step towards creativity[25].

Organizing a business game requires careful preparation by the teacher:

– determination of the lesson’s purpose;

– a division of students into groups that will perform various job duties of this chemical enterprise;

– development of tasks for each group of “specialists”.

[25] Voronenko T. Project activities of students in learning natural sciences. Biology and chemistry in native school. 2015. № 4. S. 20–24.

During the game, the following groups of specialists are created, each of which will reveal certain questions:

Participants of each group familiarize themselves with the tasks, find out the purpose and tasks set before the group, and formulate questions for which the teacher's consultation is necessary. Consultations are held in turn with each group by the teacher or subject teachers (in the case of an integrated lesson).

After preliminary training, a tour of the enterprise is conducted directly, where during the excursion, the students clarify their questions about the given enterprise. After the excursion, another clarifying consultation is held, after which the game itself is organized, during which the groups defend their tasks.

The director opens the meeting with an introductory speech about the importance of this product for industry and agriculture, revealing the relevance of this issue. In the end, he evaluates the work of the groups and summarizes them. The chief engineer directs the game and gives the floor to each group.

Such a business game can be used in the process of studying any of the chemical industries. As an example, you can conduct a business game, “I will open my plant in the future…", which can be used to generalize the acquired knowledge about chemical production.

During the business game, students can be interested in creating an interactive poster, “Chemical town," using online services.

Among the methods that contribute to the effective study of chemical productions in the course of chemistry is the use of interactive games. We recommend using the Kahoot!, Genially, etc. platforms for conducting interactive games when studying chemical production. The proposed platforms have a fairly convenient interface, bright computer graphics that attract students.

We will give examples of several questions of an interactive game created on the Kahoot! (Fig. 2.1.1).

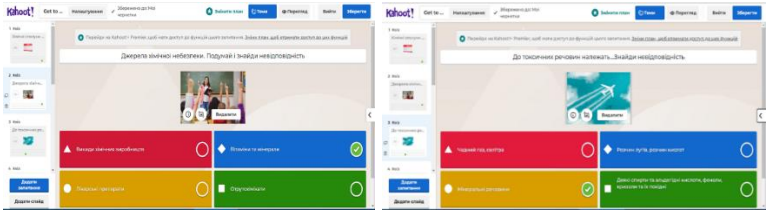


Fig. 2.1.1. Examples of interactive game tasks on the Kahoot!

The Genially platform is a multi-tasking service and offers a number of opportunities to create presentations, interactive images, quizzes, posters, videos, virtual tutorials and more. Genially allows you to organize project activities, which is important for the formation of teamwork skills in students.

Excursions and 3D production tours occupy a special place among the organizational forms of chemistry education. This is an important means of strengthening the connection of institutions of general secondary education with life. Excursions in chemistry significantly supplement and expand

students' knowledge of any process, help to better understand the regularities of its course. They activate the cognitive activity of students, not only provide new knowledge, but also have great educational opportunities.

Nowadays, the majority of chemical enterprises conduct virtual tours, which opens up the possibility of familiarization with those chemical production facilities, to which face-to-face tours are not conducted.

Excursions in chemistry are conducted to memorial and mineralogical museums, to industrial exhibitions, to chemical or close to them by nature of production, to scientific institutions, to nature.

Depending on the purpose of the educational process, there may be excursions:

1) previous ones;
2) current;
3) final.

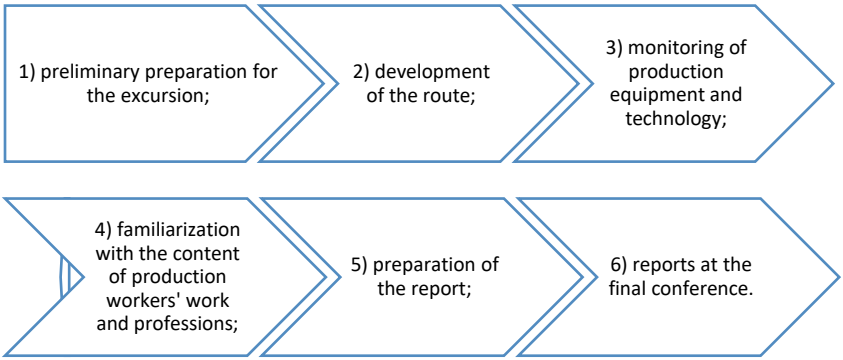
Previous excursions are conducted to obtain certain information before studying a new topic; current excursions are for learning the material being studied. Final excursions are organized to consolidate and deepen knowledge.

Industrial tours of students to industrial and agricultural enterprises to scientific institutions play an important role in terms of professional orientation. On such excursions, students get to know the main types of production activities. They get an idea of the real content of various professions and learn about the achievements of science and technology. An important moment during excursions can be visits to museums of prominent chemists, as well as memorable places related to their lives. They play an important role in instilling in students a sense of national pride for the successes of Ukrainian chemical science. Excursions into nature serve as a source of interesting material for collections and objects for further research. The topics of excursions into nature can be diverse: the search for various minerals and their further analysis, the search for natural mineral paints, etc.[26].

Excursions must be planned at the beginning of the school year and included in the institution's work plan. The main criteria for choosing the object of the excursion are the importance of the object for the national economy of the country (region), its modernity, the expediency of studying the object in accordance with the principles of local history, its compliance with the chemistry curriculum, and accessibility.

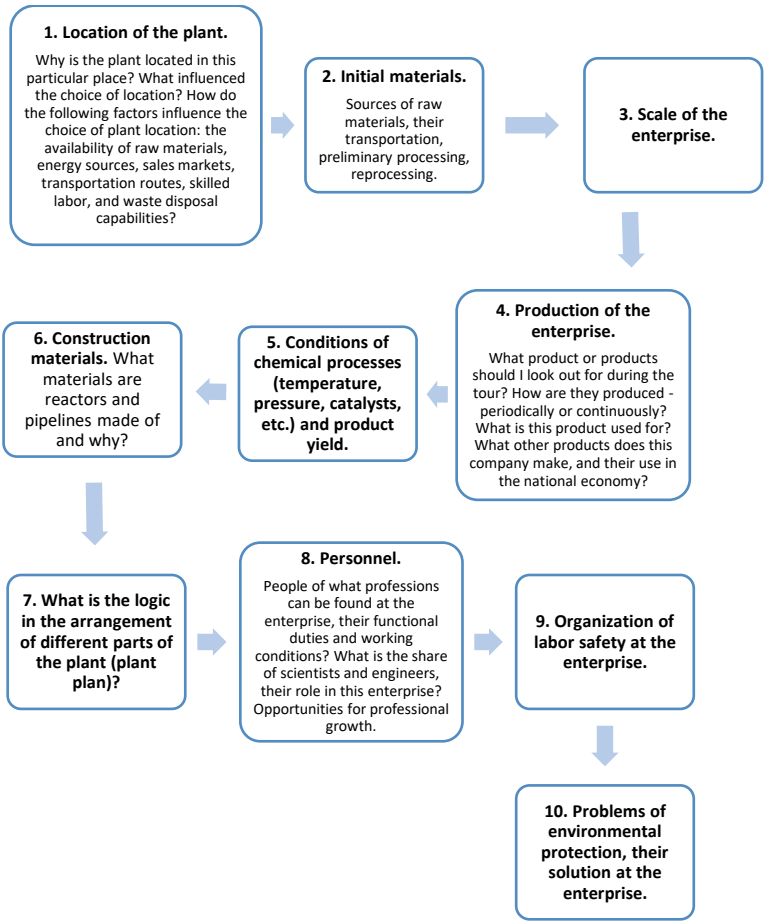
[26] Zablotska O. Impact on the environment as a link in the chain of characteristics of substances. *Biology and chemistry in a modern school*. 2013. № 6. P. 7–13.

Excursions to industrial enterprises are carried out in several stages:



The teacher, before taking students to the enterprise, must have a clear idea about it. Preparation for the excursion begins with finding out which enterprises are open for schoolchildren to visit in the city, district, or region, their directions, their connection with the programmed material, and compliance with the educational requirements. It is also necessary to briefly familiarize yourself with this product according to the literature and prospectuses of chemical plants. Taking into account the program requirements and the production environment, the teacher, drawing up the annual plan, should plan excursions by classes and topics. Having chosen the appropriate object, the teacher must meet with the tour guide in advance, inform him about the purpose and tasks of the tour, about the amount of knowledge of the students and their age characteristics, indicate which issues are especially necessary to focus on and draw the attention of the students during the explanation. In this way, the teacher gives the tour guide the opportunity to prepare for the story about the enterprise and to explain the essence of the chemical processes used in the technology.

Necessary preparation for conducting the excursion is carried out both in class during the study of the principles of chemical production, raw materials, and reactions that are the basis of production, and independently by students in the process of completing homework. Also, before the excursion, it is advisable to familiarize the students with the questions that will need to be answered during the excursion:



Excursion materials are summarized in two stages. In the first stage, immediately after the excursion, everything seen during the excursion should be reproduced. For this purpose, the teacher formulates questions for students that reflect the main points in the sequence of its implementation. At the same time, the teacher supplements the students' messages with some historical data, and modern materials from the periodical press, radio, and television.

The second stage is the preparation of written reports based on the materials of the excursions with appropriate illustrations. This can be done in the form of collections, schemes, diagrams, individual tablets, etc. The results of the excursion can be presented in the form of an album "Specialties related to chemistry", stands illustrating the work of the enterprise, and so on.

Among the virtual excursions that we recommend to be used in the process of studying the basics of chemical production in the course of chemical Institution of General Secondary Education – are excursions to enterprises of the Sumy region. For example, a virtual excursion to OJSC Pharmaceutical Company "KusumPharm", during which students have the opportunity to get acquainted with the enterprise, products, and the chemical-technological production process in general. We present several slides in Fig. 2.1.2. from a virtual tour.

Fig. 2.1.2. Screenshots of the virtual tour

In the process of studying the basics of chemical production in the chemistry course, it is effective to use various modern IT technologies, such as 3D tours of chemical production, virtual laboratories, and simulators, video presentations of modern productions of Ukraine and the world, etc.

Wide use of animation and simulation of chemical productions allows to present of complex material in a more understandable visual form, which is better remembered. The use of virtual tours and 3D production tours helps broaden students' horizons and makes it easier to understand the essence of chemical production.

We recommend that you turn to 3D tours in order to deepen the knowledge gained in chemistry lessons. As an example, you can single out a 3D excursion to the pharmaceutical production "Darnytsia" (https://www.darnitsa.ua/tour). Fig. 2.1.3. several screenshots of a 3D tour of the pharmaceutical production "Darnytsia"

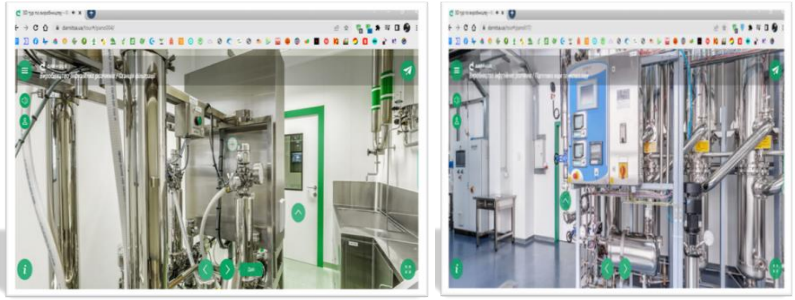


Fig. 2.1.3. Screens of a 3D tour of the pharmaceutical production "Darnytsia"

During the excursion, students get acquainted with the chemical laboratory, its equipment, the technological process, and the storage conditions of both raw materials and finished products. It is very important that students in the process of studying the course chemistry study directly chemical productions and support the knowledge gained in the lessons with practical understanding.

Such excursions allow students to immerse themselves in the world of chemical production, provide an opportunity to add experience and consolidate the theoretical material worked out in chemistry lessons, and possibly choose a future profession.

An important role in the process of learning the basics of chemical production is the solution to problems of production content. When solving problems of this type, reproductive types of students' cognitive activity dominate, when they perform actions either according to the sign shown by the teacher or with the help of instructions.

When solving problems of industrial content, it is necessary to gradually form in students the ability to solve problems of this type, since students experience difficulties in operating with large numbers, and performing cumbersome calculations using unusual units of measurement (tons, cubic meters, etc.). At the same time, students' attention is diverted from the chemical essence of the question, they often make arithmetical mistakes. Compliance with the requirements of the International System of Units (Cl), as well as the use of computer technology, will help to avoid these shortcomings.

The forms of solving problems of industrial content can be different: oral, written, or practical (experimental). Chemical problems, including those with production content, depending on whether mathematical calculations are needed for their solution or not, the latter is divided into: computational and qualitative.

Examples of problems with production content can be the following:

Calculation problem. Natural gas from the Dashava field contains 90 % (by volume) of methane. What volume of Dashava gas is used for the production of hydrogen with a volume of $1.12 \cdot 105$ m^3 obtained by cracking methane?

Quality task. Three packages without labels contain mineral fertilizers: nitrate, chloride, and potassium phosphate. How can you recognize each of the substances?

The form of performance of the calculation task can be oral or written, qualitative – oral, written, or experimental.

In the process of studying the basics of chemical production, it is important to use all types of problems of production content. This gives students the opportunity to apply the acquired knowledge in various educational situations and will contribute to a better understanding of many theoretical concepts from the basics of chemical production.

In order to use the task of production content to be most effective, a number of conditions must be met. Yes, the content of the task should:

 be related to progressive processes that reflect the current state of chemical technology and which are implemented in chemical, metallurgical, petrochemical industries studied under the program;

 to provide students with the application of knowledge about chemical reactions that are the basis of production, typical devices, stages of the technological process, and properties of raw materials and products. This knowledge will contribute to a more informed understanding of the scientific foundations of modern production;

 be such that it is possible to solve the problem in parallel with the study of specific chemical production;

 contribute to the disclosure of the nature and scope of the chemicalization of the country's national economy.

It is also advisable to include information on the professional activities of chemical specialists in the content of the tasks of the industrial content.

Let's focus on the effectiveness of using interdisciplinary connections in the process of forming knowledge about the basics of chemical production.

In our opinion, the skillful use of interdisciplinary connections is an important factor in the optimization and intensification of the educational process, increasing the effectiveness of its quality.

In the process of forming concepts during the study of sulfuric acid and its production, it is quite possible to use information from the geography course – natural resources and areas of their distribution. In the course of chemistry, biology, and geography, there are also other topics where intersubject connections can work successfully, and it is possible to implement them by

solving calculation and experimental tasks, in the process of teaching the programmed material[27].

When familiarizing students with the basics of sulfuric acid production and its industrial significance, it is appropriate to use knowledge from the course of economic geography (natural resources, placement of raw materials for the production of H_2SO4, use of non-ferrous metallurgy waste, and in this regard, highlighting the problem of economical use of raw materials.

Having analyzed the curricula of these subjects, we concluded: it is more expedient to conduct integrated lessons during the study of chemical industries since in the process of considering these topics, knowledge of both geography and chemistry is necessary. This includes knowledge of minerals, their chemical composition, their location, technological processes that underlie the extraction of metals and alloys, etc.

In the process of studying chemical industries, special attention should be paid to environmental issues.

In the chemistry textbooks recommended by the Ministry of Education and Science of Ukraine, issues of environmental orientation are reflected quite concisely. But such educational material is extremely important for the formation of ecological competence of young people, especially in our time when it is recognized that there is an ecological crisis in Ukraine. Visualization of ecologically oriented educational material contributes to the effective assimilation of knowledge of the basics of the natural environment during chemical processes and the prevention of the negative impact of chemicals on environmental objects and human health.

In the chemistry program, for example, in the 7th-9th grade, there are no questions of environmental orientation, with the exception of three (Hydrocarbon raw materials and environmental protection. Use of hydrocarbons; Environmental protection from persistent organic pollutants; Chemical science and production in Ukraine). However, a number of topics are very closely related to issues of environmental protection, reduction of pollution of natural waters, soils, air, food, etc. The role of chemistry in preventing pollution of environmental objects must be considered in all main topics (“Solutions”; “Electrolytic dissociation”; “Chemical reactions and their basic laws”, etc.).

Therefore, in the process of learning the basics of chemical production, teachers should place considerable emphasis on the environmental consequences of chemical processes.

[27] Nazarenko T. G. Formation of students’ environmental competence in geography lessons. *Ukrainian Pedagogical Journal*. № 1. Kyiv, 2017. P. 59–65.

The greening of the content of the chemistry course of Institution of General Secondary Education can be illustrated by examples of some key topics.

So, even in the process of studying the topic "The most important chemical concepts" in the 8th grade, students should get an initial idea about a chemical element and concepts related to it. In addition to theoretical knowledge, students acquire practical skills in conducting a chemical experiment, for example, during the purification of substances, and separation of mixtures. In this regard, it is possible to familiarize students with a number of concepts of environmental nature – pollutants, sources of pollution, and modern methods of cleaning substances in the industry. The students come to the conclusion that it is economically more profitable to prevent environmental pollution than to restore the destroyed for a long time and at great expense.

The influence of human economic activity on the cycle of oxygen in nature is discussed: the destruction of forests, pollution of the surface of the world's oceans, and huge consumption of oxygen for the needs of industry.

In the process of discussing measures to combat air pollution, the concept of rational use of natural resources is developing and new concepts are being introduced: "economically harmless" and "waste-free" technologies.

Students can be introduced to measures to protect the air from pollution:

– proper fuel burning;
– construction of treatment facilities;
– replacement of fossil fuels with alternative energy sources;
– improvement of production technology and modernization of motor vehicles;
– expansion of green areas.

During the study of the basics of chemical production, environmental tasks are solved using the concept "Product yield in the percentage of theoretically possible", for example: "At the ammonia production plant, the planned product yield was 17 %. Ammonia leak due to equipment malfunction reduced yield by 1 %. Find the mass of ammonia released into the environment if 60 kg of hydrogen was consumed in the reaction. What negative effect can ammonia cause when it gets into the air and water?

We consider it necessary to review the importance of chemical production in organic chemistry.

The organic chemistry course is quite difficult to understand and learn. Students often lose interest in it after the first topic. However, it is difficult to overestimate the worldview significance of the study of organic substances, which make up the entire natural world of the Earth and each of us. Environmentalization of the course of organic chemistry will help introduce the student to this world "from the inside" and reveal not only the peculiarities

of the structure and properties of biomolecules, but also the problems that arise in living organisms, individual ecosystems, and the biosphere as a whole.

Knowledge of the listed laws will help students to approach the analysis of the structures of organic compounds in a more meaningful and purposeful way and to predict their effect on living objects of nature.

Thus, in the process of studying methane, information is provided that expands students' understanding of its role in the biosphere, and its use in biotechnology and organic synthesis. Methane and other gaseous hydrocarbons entering the Earth's atmosphere over thousands of years do not accumulate in it. Methane, in particular natural gas, is considered a promising raw material for the creation of a large-scale protein synthesis industry. Biomass obtained by growing bacteria on methane or natural gas is a product that is not inferior to soy flour or dry milk in a number of indicators. The protein content in biomass is 57–75 %. According to its amino acid composition, the protein of methane-oxidizing bacteria is a complete nutritional product. Moreover, according to the content of lysine, sulfur-containing amino acids, tryptophan, and valine, the biomass of bacteria on methane exceeds the biomass obtained from other types of raw materials.

However, methane-based biosynthesis has not yet been implemented on an industrial scale. Difficulties are associated with equipment design and safety equipment in the process of working with methane-air mixtures (aerobic process). There are also purely biological problems (natural gas substances such as ethane, propane, and butane, as well as ethane transformation products – ethanol and acetaldehyde, NH_4^+ ions introduced into the environment, and NO_3^- ions accumulated in the process of denitrification and nitrification significantly reduce the rate of methane oxidation and accordingly reduce the growth rate of crops). All this affects the productivity of the protein biosynthesis process.

When characterizing freons, it should be indicated that they are gases or easily boiling liquids. They have a unique set of properties: chemically inert, non-flammable, non-explosive, non-toxic, insoluble in water, but soluble in organic solvents. The use of freons has opened up new opportunities for food storage in industrial and household refrigerators, storage and dosing of liquids (in the form of aerosols), they are used in automatic fire extinguishing systems ($CBrF_3$) and as solvents ($C_2Cl_3F_3$).

Several years ago, a hypothesis was put forward about the adverse effect of freons (mainly CF_2Cl_2 and $CFCl_3$) on the ozone layer. It is believed that freons decompose under the action of ultraviolet solar radiation with the formation of a large number of different compounds and radicals of the Cl*, Cl_2* type.

Calculations show that the rate of formation of chlorine atoms should be maximum at an altitude of about 30 km. However, the rate of diffusion of freon molecules from the earth's surface into the stratosphere is not very high due to their significant molecular weight, so it is unlikely that freon is the cause of the destruction of the ozone layer.

However, it should be emphasized that in a number of countries a decision was approved to reduce the production of freon, and in the future, to completely stop it. As alternative refrigerants, for example, you can use less volatile fluorochloromethane, and in aerosol packages – liquefied gaseous kinds of paraffin.

In the process of studying the basics of chemical production, the use of a chemical experiment with an ecological content is quite significant.

A chemical experiment is an integral part of learning chemistry. In conditions of Environmentalization of chemical education, the role of the experiment is increasing. It becomes an active method of studying the natural environment, forming and improving knowledge in the field of chemistry, ecology, and nature protection. Under the guidance of the teacher, students must analyze various environmental situations, predict the functioning of natural systems in conditions of anthropogenic action, and find solutions aimed at protecting and preserving the habitat.

Currently, the environmentalization of a chemical experiment takes place in two directions:

1) use of analytical methods to determine the state of the natural environment;

2) processing of waste generated as a result of chemical reactions (destruction of substances, their neutralization with subsequent transfer to the external environment or reuse in the production process).

Explaining natural phenomena and processes using a chemical experiment, studying the effect of substances on living organisms and ecosystems, and developing an ecologically safe experiment will help to reveal the unity of living and non-living nature.

Greening of the program experiment is carried out in three directions:

– the chemical content of the experiment is preserved, but the environmental cleanliness of the experiment, which is achieved by good sealing of the laboratory equipment, becomes a mandatory element; neutralization or neutralization of reaction products; replacing reagents hazardous to students' health with safe ones;

– the content of the experiment is preserved, but it is focused on an environmental problem;

– "chemical" content is replaced by ecological content while maintaining the semantic load of the experiment or the thematic section of the course.

Environmentalization of a chemical experiment is impossible without including a research component in it. Only in this case, students develop a wide range of practical skills, develop the skills of formulating a problem, planning an experiment, conducting observations, collecting data, mastering various research methods and techniques, processing, analyzing and discussing the results, assessing the real environmental situation and predicting the consequences of application nature protection measures.

The research component can be implemented through a system of non-traditional chemical experiments, the basis of which is:

1) simulation of ecological situations adequate to the real ones;
2) imitation of some natural processes and phenomena;
3) determination of biogenic elements in biological material;
4) assessment of the quality of agricultural products.

Greening a chemical experiment will make the perception of theoretical material more active, emotional, and creative, and will contribute to the formation of students' interest in chemistry and ecology.

One of the most important topics – "Chemical reactions" – is considered in the 9th-grade chemistry course. Traditionally, this topic is considered using examples of substances that are not natural. For students, such information is abstract. However, if students are offered a generalization of the types of chemical reactions using environmental issues, their interest in chemistry increases significantly. Also, in our opinion, it will be effective to use a demonstration experiment when studying this topic. Here are some examples:

Demonstration experiment 1. Anthropogenic effect on natural systems. We demonstrate processes imitating acid rain, acidification of water bodies, salinization of soils when excessive doses of mineral fertilizers are applied, destruction of eggshells under the action of acids, suppression of plant growth in conditions of excessive content of metal ions (especially heavy ones) in the soil, etc.

Demonstration experiment 2. Chemical protection of the place of existence. We demonstrate the processes of cleaning wastewater or polluted water bodies using coagulants (for example, aluminum sulfate), simultaneous utilization of sulfur (IV) oxide and hydrogen sulfide (an example of environmentally friendly technology), reducing the acidity of water bodies or soil during liming (for example, when using eggshells) and others

It is recommended to assess the quality of students' practical knowledge and skills according to the following criteria:

1. The ability to plan the sequence of actions when performing an experiment (knowledge of experimental technology).

2. The ability to distribute responsibilities when performing an experiment in pairs or groups.

3. Knowledge of safety rules when working with chemicals and laboratory chemical utensils.

4. Ability to use laboratory chemical utensils.

5. The ability to observe the processes that occur during an experiment in the school classroom, and to draw conclusions about the peculiarities of their course in production.

6. Predict the possibilities of an unsuccessful course of the experiment and ways to overcome them.

In environmental education, methods of game-based active learning are considered to be priority methods[28]. There are three groups of games:

1) games introducing the essence of nature protection problems;

2) games that initiate the creative activity of students in the field of finding specific solutions to environmental problems;

3) games that allow you to acquire practical skills in studying and assessing the ecological state of the area, modeling the ecological well-being of the given territory, conducting an ecological examination, and collective discussion of the problem and ways to solve it.

Control tasks must correspond to the level of formation of environmental knowledge in students and must be combined with the emotional, ethical, and behavioral sides of each of them.

Various chemical processes are the basis of numerous industries. Chemical products are used in all branches of industrial and agricultural production, and technology, and are widely used in everyday life.

Social, civil, and professional self-determination of young people and the preparation of school graduates for continuing education in vocational education institutions become a priority task for future graduates of Institution of General Secondary Education. Young people learn the content of education much better if it is presented in a form that is directly related to their personal experience, their own needs, and their cognitive and professional interests. Therefore, approaches to building the content of education at the senior level of school should be differentiated. For profile courses, the visual structure should be preserved, for basic courses, the expediency of building integrated courses may be considered.

As shown by studies conducted by various teachers, students are not interested in studying chemistry, because this discipline does not lie in the field of their interests. But it can be seen from the above that the academic discipline “Chemistry” is part of the basic educational component and is mandatory for study in all educational institutions of various profiles. It is

[28] Motorna L. V. Systematic approach in the field of environmental education and training in universities of the I-II levels of accreditation. *Problems of education*: scientific and methodological collection. Third special edition, 2006. P. 333–337.

necessary to ensure the minimum chemical knowledge of students in accordance with the requirements of the state educational standard. Thus, on the one hand, we have the professionally oriented interests or inclinations of students to study economics and law, and on the other hand, the need to provide students with a minimum level of knowledge in accordance with the requirements of the state educational standard. This contradiction must be resolved through the integration of knowledge of specialized subjects (in this case, economics) and the basic course of "chemistry" (which is studied either as part of the integrated course "Natural Science" or as an independent subject). That is, it is necessary to use the cognitive or professional interests of students in the process of studying chemistry as a motivational factor.

The following methodical tools can be used to introduce an economic component into the course of the chemistry of the Institution of General Secondary Education:

1. Introduction of economic concepts in the course of chemistry. The content of economic concepts is revealed on chemical material.

2. Solving chemical problems, and issues with interdisciplinary (technological and economic) content, in the process of studying topics related to chemical production.

3. Modeling business situational games. In the process of learning, in the form of game situations, economic activity is simulated in practice (business games, role-playing games, etc.), which significantly increases interest in the subject and increases motivation.

In order to highlight a number of economic concepts that can be included in the course of chemistry in the process of studying one or another topic, educational programs, and textbooks on chemistry and economics were analyzed. As a result of the analysis, the following economic concepts were identified: economic efficiency, cost price, and saving of raw materials, which can be expanded during the study of the topics "Hydrocarbons", "Oxygen-containing organic substances"; raw materials, complex use of raw materials, optimal production conditions, products – these economic concepts can be filled with chemical content by studying any topic related to chemical production. We will consider the formation of the integrated concept of "cost" in the course of chemistry on the example of the topic "Concepts of polymers on the example of polyethylene" and the production of polyethylene. In the chemical industry, in most cases, the cost of production is determined by the raw material factor. First of all, students define the term "raw material". "Raw materials – natural materials (natural resources) that are used in industry to obtain various products and that have not undergone industrial processing." During the formation of the concept of "raw material", students reveal the following concepts listed in Table 2.1 (on the example of a specific topic).

Table 2.1

Chemical and economic component of the concept of "raw material"

RAW	
Chemical component	**Economic component**
– Initial raw materials: classification – Processing methods (as processed); – Degree of conversion of raw materials (product output) + cost; – Comprehensive use of raw materials.	– Sources of income (local, imported); – Availability of raw materials (expensive, cheap; renewable, non-renewable; primary or secondary) – Economic costs of delivery and processing of raw materials.

The main criterion for choosing raw materials is their economic efficiency.

The initial raw material for obtaining polyethylene is ethene, which can be obtained from: a) alcohol; b) halogen derivatives of ethane; c) secondary processing of raw materials. Students evaluate the economic efficiency of raw materials (alcohol or ethane halogen derivatives) for obtaining ethylene.

By tasks with interdisciplinary content, we mean tasks, and questions, during the solution of which students involve knowledge of chemistry and economics. Examples of tasks with interdisciplinary (technological and economic) content can be considered during the study of any topic of the organic chemistry course related to chemical production. For example, students of the "humanitarian" profile are very interested in finding answers to the following task:

Explain the words of D. I. Mendeleev: "Oil is not fuel – it can also be fueled with appropriations (money)." "Oil is a rare product of nature, it should be given a completely different application than for fuel." In connection with what D. I. Mendeleev expressed these thoughts?

Students also find answers to the following tasks and questions of interdisciplinary content:

1. *List the natural sources of hydrocarbons. What is the significance and application of associated and natural petroleum gases in modern economic production?*

2. Obtain Ethanal in three different ways. Compare the economic efficiency of the specified methods based on the cost of raw materials.

3. What are the main stages of the production process of obtaining acetic acid from calcium carbide? What devices exist for this? In which of them are carried out: a) catalytic processes; b) oxidizing processes; c) hydration; d) principle of countercurrent; e) principle of direct current; e) circulation processes.

4. What is meant by a waste-free technological system? List the main directions in which waste-free production is developing.

5. The transition to waste-free oil refining technologies is carried out in two main ways:

a) increasing the completeness of the use of raw materials (when implementing combined technological installations of large unit capacities);

b) replacing water cooling at oil refineries with air. Give examples, and reveal ways to transition to waste-free technologies.

6. Propose an optimal (waste-free) synthesis scheme of vinyl chloride, starting from ethylene.

Considering the simulation of business situational games, we offer a business game "Pulp and paper production", which can be conducted in order to learn chemical, economic, and integrated concepts. In the course of this game, the situation of "meeting with the director" is simulated. The issue of developing optimal conditions for paper production and product sales at the plant is being resolved. Deliver reports and participate in the discussion of production issues: "Supply Department", "Technical Department", "Laboratory", "Economic Department", director, and ecologist.

Business games develop in students the skills of joint activity and the rules of behavior during the discussion.

A special place in the chemistry course is also holding lessons dedicated to the tragedy at the Chornobyl NPP.

Chemistry is one of the important subjects in the system of general education for high school students, as it has special methods of studying nature, fundamental scientific theories, and laws. Chemistry is a subject, during the study of which, the Chernobyl accident is the most vivid example, demonstrating that the processes studied in the lessons are not only related to abstract scientific theories or industrial activities, an example of the fact that chemistry is inextricably linked to everyday life. Studying the circumstances, and technical and chemical aspects of the Chernobyl disaster allows us to deepen our understanding of some sections of chemistry, terms, and concepts, to connect them with reality. Analysis and awareness of the consequences of that terrible accident can contribute to the implementation of the educational tasks of the educational process and will allow the teacher to go beyond "office knowledge".

We would recommend devoting an entire lesson to the subject of the Chernobyl disaster. Conducting a lesson in the form of a seminar can be the most effective. The most prepared students can make a report, and from the beginning of the lesson, the teacher can talk about aspects of the Chernobyl accident that are indirectly related to the chemistry course of Institution of General Secondary Education (such as the organization of chemical production, ensuring safety, the effect of radiation on the body, etc.), as well

as give general information about the time, place of the accident, and its consequences. It is necessary to conclude the lesson with generalizations.

Thus, in studying chemical production, we recommend combining various methods. Still, we consider the most priority – conversations, discussions, business, interactive games, conferences, production tours and 3D tours of production, etc. For more effective and deep assimilation of the acquired knowledge by students, teachers should use a variety of didactic material – stands, tables, photos and videos, interactive posters, etc. When studying this aspect, in our opinion, one should not limit oneself to the description of schemes of production processes, models of individual units, and operating models that reflect the essence of the work of this production. It is better to use the opportunity to consolidate a course on the scientific principles of chemical production, the relationship between chemistry and society, chemical production and the environment, and ensuring safety in chemical and other hazardous productions.

CONCLUSIONS

The rapid development of the industry, including the chemical industry, requires adequate, highly qualified specialists, professionally competent, operative, and able to identify non-standard approaches in matters of improving production, especially in the direction of increasing environmental safety.

An important factor in training a highly qualified specialist in the future is modern institutions of general secondary education, which, unfortunately, do not fully utilize the possibilities of professional orientation of future graduates with an emphasis on a conscious choice of profession.

In this regard, we found a contradiction between the need to strengthen the applied orientation of chemistry education in Institution of General Secondary Education and the limited time allocated to studying the basics of chemical production. This, in our opinion, limits the possibilities of implementing the applied orientation of chemistry in lessons; therefore, for this reason, teachers are forced to give preference to the study of the basics of the science itself.

The research results show that a formal approach is used in learning the basics of chemical production, and the materials used in the lessons often need to be more relevant. Connection with life is sporadically used, and only a small part of chemical production is studied based on local material. Teachers pay insignificant attention to the use of design learning technology in studying chemical production; the elements of research, experimental and problem-based approaches still need to be fully implemented. Interdisciplinary connections with related sciences (geography, physics, biology, ecology) are only partially used, which makes the study of chemical production one-sided, limited and uninteresting.

The theoretical foundations of the formation of subject competence in chemistry are considered, and the peculiarities of chemistry teaching and methodical approaches to the study of chemistry in Institution of General Secondary Education are revealed, in particular, in the issues of studying the basics of chemical production.

According to the results of the theoretical analysis of the scientific and pedagogical literature and regulatory documents, it was established that the subject chemical competence of students is a component of the key competencies "Competence in the field of natural sciences" and "Environmental competence."

We consider *subject competence in chemistry* as the student's ability to navigate life situations, make evaluative conclusions, and effectively solve current problems that involve working with concepts such as chemical elements, substances, chemical phenomena, and chemical production. That is, studying the basics of chemical production is one condition for forming subject competence in chemistry.

In the process of teaching chemistry, the teacher must be shown that chemistry not only creates new substances, materials and processes that pollute the environment but also develops production cycles that work according to the principle of natural processes when there is no "falling" of chemicals from the circulation, when waste one production is a raw material for another, etc. In studying the basics of chemical production, special attention should be paid to the formation of students' ecological culture and a conscious attitude to environmental protection.

We offer to study the basics of chemical production in institutions of general secondary education based on the organization of practical scientific research activities of students – by involving students in solving modern environmental problems at lessons-conferences, business and interactive games, web quests, etc.

As a result of the conducted research, we confirm that the use of IT technologies in the study of chemical productions in chemistry lessons provides ample opportunities not only to visualize the educational material on this topic but also to familiarize students with modern chemical productions using excursions and 3D tours of the production, using virtual laboratories and simulators, platforms for conducting interactive games on the study of chemical industries, etc.

SUMMARY

The modern development of science and technology reaches large scales. Chemical production in Ukraine is trying to reach a new level, updating the technological process, devices, etc. Instead, chemical production needs highly

qualified specialists with the skills and abilities to master the latest equipment and devices. Analysis of the labor market revealed the presence of a sufficient number of vacancies for employment in chemical production. All these facts indicate the need to strengthen the emphasis on the training of specialists for chemical industries, starting with the Institution of General Secondary Education. This requires strengthening the applied orientation of chemistry education in the Institution of General Secondary Education and increasing the hours for studying the basics of chemical production. Chemistry teachers should pay attention to the importance of studying chemical industries for the formation of students' professional orientation.

Studying the basics of chemical production using IT technologies in chemistry classes, especially in the period of distance learning, provides a wide range of opportunities, namely: visualization of educational material, use of 3D production tours, virtual laboratories and simulators, construction of graphic and 3D models of chemical structures and substances, etc. According to the results of the conducted research, we state that a comprehensive approach using various methods and forms contributes to the effective assimilation of students' knowledge of the basics of chemical production and the ability to make a comprehensive assessment of their activity, contributing to the formation of subject competence in chemistry.

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